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Article

Relationship of BMI with COVID-19

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Abstract: Body mass index has been studied as one of the factors that negatively influences COVID-19. In this work we intend to analyze this influence. A representative sample of the population of Beira Interior was used (around 2%), to which immunity research and a socio-demographic survey were carried out. It was found that obesity influences the vaccination rate, and all other variables analyzed were not influenced by the body mass index.

Keywords: COVID-19; body mass index; vaccination; evolution

1. Introduction

COVID 19 was a pathology that surprised the entire Planet, with its ability to transmit itself to all countries very quickly, putting the entire scientific community into complete shock [1].

Its origin still requires more concrete studies, but everything suggests that it was a transmission of a virus from animals to humans, with known catastrophic effects.

COVID-19, in addition to the deaths it caused in the human population, also contributed to the exhaustion of health systems worldwide and thus was responsible for many other deaths, indirectly, since there was no space and capacity to, for example, cancer screening programs [1].

COVID 19 is an infectious respiratory disease, associated with SARS-COV-2, a virus belonging to the coronavirus. These have been known for more than 60 years and have a huge history of infections in both humans and animals, but always associated with mild respiratory infections and without great significance from the point of view of negative evolution. Children always appeared as the most prevalent group, particularly those of younger ages [2].

However, it is important to remember that there were coronaviruses associated with more serious pathologies, such as Acute Respiratory Syndrome (SARS), which began to spread in 2002 from China and was controlled in 2004. Later, in 2012, A. A new situation emerged, particularly in Saudi Arabia and neighboring countries, and was designated as Middle East Respiratory Syndrome [3].

Thus, the most common coronaviruses in general are associated with respiratory infections in Human Beings, which can be classified, in the majority, as mild or moderate. The main symptoms are cough, sore throat and increased body temperature. In situations of greater vulnerability of the infected human being, viruses may be able to reach the lower respiratory tree, thus invading the lungs and causing viral pneumonia. This vulnerability is usually associated with cardiovascular diseases, low immunity (associated with several underlying pathologies) and metabolic diseases, in which, in addition to diabetes, obesity may also be considered. There are also other conditions that can contribute to a negative outcome, such as age (in this case the explanation could be a more exhausted immune system, for example) [4].

The usual incubation period varies between two and fourteen days. The period of transmission is associated with the period of symptoms (including symptoms that can contribute to spread, such

as coughing, for example), but it is important to highlight that in other phases of the disease it is also possible to have contamination from other human beings [4].

This contamination occurs through direct contact between human beings, but there is also a description of transmission through contaminated surfaces. All human behaviors that may contribute to an increase in the number of people in the same space, decreased ventilation or crowding are increased risks [1].

The diagnosis of COVID-19 can be made after medical evaluation and by carrying out the Nucleic Acid Amplification Test (TAAN): for the detection of virus RNA, carried out with samples collected through a swab from the nose and/or of the throat or the Rapid Antigen Test (TRAg), which are proximity tests carried out with samples collected through a swab from the nose and/or throat region [5].

It is possible to prevent the transmission of SARS-COV-2, using various methodologies, such as the use of a mask, the adoption of respiratory etiquette (when coughing or sneezing, covering your nose and mouth with a tissue or your arm and then throw the tissue in the trash and wash your hands, or use an alcohol solution with at least 60% alcohol), wash and/or disinfect your hands frequently, clean and disinfect equipment and surfaces, especially those that are most touched, maintain physical distancing and avoid closed or crowded environments, keep spaces ventilated, preferably through natural ventilation, opening doors and/or windows and vaccination [6].

Vaccines were one of the main turning points in the COVID-19 pathology, as they contributed very effectively to the end of the pandemic. From the existing knowledge in science there are several main approaches to designing a vaccine. The differences are based on the methodology used: using an entire virus or bacteria that transmits the disease, or a very similar one, and inactivating or killing it using chemicals, heat or radiation. This approach uses technology that has been proven to work on humans. However, it requires special laboratory facilities to safely grow the virus or bacteria, can have a relatively long production time, and will likely require the administration of two or three doses; similarly, a live but weakened version of the virus or a very similar version can be used. This approach uses technology similar to the inactivated vaccine and can be manufactured on a large scale. However, vaccines like this may not be suitable for people with compromised immune systems. On the other hand, it is possible to use only components that awaken the Immune System and use genetic material that provides instructions for the production of specific proteins and not the entire virus. This type of vaccine uses a safe virus to deliver specific subparts – called proteins – so that it can trigger an immune response without causing disease. To do this, instructions for producing specific parts of the target of interest are inserted into a secure virus. The safe virus then serves as a platform or vector to deliver the protein to the body. The protein triggers the immune response. There is also the possibility of a subunit vaccine, which uses only very specific parts (the subunits) of a virus or bacteria that the immune system needs to recognize. It does not contain the complete microorganism nor does it use a virus as a vector. Unlike vaccine approaches that use an entire weakened or killed microorganism or parts of one, a nucleic acid vaccine uses only a section of genetic material that provides the instructions for specific proteins. DNA and RNA are the instructions our cells use to make proteins. In our cells, DNA is first transformed into messenger RNA, which is then used as a template to produce specific proteins. A nucleic acid vaccine delivers a specific set of instructions to our cells, either as DNA or mRNA, to produce the specific protein that we want our immune system to recognize and respond to. The nucleic acid approach is a new way to develop vaccines. Before the COVID-19 pandemic, none of them had yet gone through the full approval process for use in humans, although some DNA vaccines, including for specific cancers, were undergoing human trials. Due to the pandemic, research in this area has progressed very quickly and some mRNA vaccines for COVID-19 are receiving emergency use authorization, meaning they can now be administered to people in addition to only being used in clinical trials [7, 8, 9].

The COVID-19 pandemic revealed several phases along its path, being a constant and permanent learning process. As the pathology advanced, science also expanded knowledge, from the form of transmission, through treatments and prevention, particularly with the creation of vaccines, which revolutionized the transmission route of SARS-COV-2.

There are underlying diseases that predispose to greater severity, such as high blood pressure, cardiovascular problems, asthma and obesity, among others [1], but there are also genetic changes that can contribute to a negative evolution of the pathology [10,11]. People who had one of these previous pathologies were always the most affected, with much more severe effects, but there are also reports of negative developments in People, who initially would not have associated risk factors.

On the other hand, there are some factors that can act as protection against negative developments, such as the individual's healthy state and previous vaccination [12]. Also, here, similar to what was previously described, people with good prognostic factors developed negatively, without an apparent justification.

The relationship between body mass index and the consequences of COVID-19 has often been explored and analyzed, in order to understand the implications for the natural evolution of the disease and long-term COVID. Increasing knowledge about the pathology caused by SARS-COV-2 is a scientific imperative and many studies have been carried out in this field [13], which have proven to be indispensable for increasing control and treatment capacity.

2. Materials and Methods

2.1. Objective

Analyze the impact of Body Mass Index on the pathology caused by SARS-COV-2.

2.2. Methodology

The *Beira Baixa com Vida Project*, where this work is integrated, arose from the need to monitor and evaluate the influence of SARS-COV-2 in a region in the interior of Portugal, with low population density and where the population has increased difficulties in accessing health.

To carry out this work, integrated into the "*Beira Baixa com Vida Project*", one thousand five hundred and fifty-two individuals were involved. A whole blood sample was collected to assess immunity and a socio-demographic survey was carried out (sex, weight, height, BMI, previous pathology, symptoms during COVID-19, vaccination for SARS-COV-2, test RT-PCR for SARS-COV-2).

The BMI classification was based on five subtypes: normal, overweight, grade I obesity, grade II obesity and morbid obesity, in accordance with other articles in the area [14] and with European WHO guidelines (<https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index>). The body mass index was calculated following the standards defined by the World Health Organization (WHO).

Immunity was assessed by searching for antibodies using the YHLO UNICELL system. According to the manufacturer's instructions, an individual is considered to have a concentration of neutralizing antibodies sufficient to confer immunity against SARS-CoV-2 when this is greater than ten AU/mL.

Symptoms were analyzed individually and organized into four levels, according to the existing bibliography: asymptomatic, mild, moderate and severe [15].

Information was collected by "self-report", in accordance with practices used in other similar articles [16]. This type of information collection allows the individual to explain in detail the pathologies they have.

The Ethics Committee of the Polytechnic Institute of Castelo Branco approved this study on the fourteenth of July 2021 (33/CE-IPCB 2021). All subjects consented to the research, including personal and health data and the collection of a venous blood sample. All individuals had access to the theoretical part of the project, read and filled out the "informed consent" and were informed that they could withdraw from the project at any time, without any consequences. All the most correct ethical precepts were taken into consideration and the Declaration of Helsinki was respected.

3. Results

The sample consisted of 1552 individuals, 64% male and the remaining 36% female. It had an average age of 48.95 years, with a minimum of 18 and a maximum of 98 years.

According to the body mass index classification defined in five levels, it is observed that 41.4% of the sample is of normal weight, 37.4% is overweight, 15.0% is class I obese, 3.2% in class II obesity and 1.5% in morbid obesity. In 1.5% of the sample it was not possible to calculate the value.

Regarding vaccination, 97.9% of individuals had been vaccinated and the remaining 2.1% reported that they had never received any dose of the vaccine against SARS-COV-2.

When analyzing the relationship between BMI and vaccination, we verified the existence of statistically significant differences, since individuals classified in the four highest categories have a higher percentage of being vaccinated compared to individuals classified as "normal weight".

Regarding the type of vaccine (commercial brand), we observed that the majority of people were vaccinated with Comirnaty (PFIZER) (38.9%), 20.2% with Spikevax (Moderna), 11.7% with Vaxzevria (Astrazeneca) and 4.8% with the Janssen vaccine. The remaining individuals took doses combining different types of vaccines, with emphasis on 10.4% with Vaxzevria and Comirnaty, 7.2% with Vaxzevria and Spikevax, 2.8% with Janssen and Comirnaty, 2.6% with Janssen and Spikevax and 1.4% with Spikevax and Comirnaty. If we analyze these data taking into account the body mass index we observe that there are no statistically significant differences in the type of vaccine administered.

Regarding the previous existence of a positive COVID-19 RT-PCR test, it is observed that 32.3% of individuals had previously tested positive (501 people), indicating that they had had SARS-COV-2 pathology. It is observed that there are no statistically significant differences.

Regarding the symptoms developed by individuals with a positive RT-PCR test, it is clear that only a small fraction (14.6%) were asymptomatic, 69.8% had mild symptoms, 14.2% moderate and 1.4% severe symptoms. No statistically significant differences were observed in the analysis of BMI by symptomatology developed.

Analyzing the specific symptoms during COVID-19 pathology among the 501 individuals with a positive RT-PCR test result, it was observed that 63% had headaches, 55.9% had cough, 54% had odynophagia, 46% had gastrointestinal symptoms, 42.8% had an increase in temperature (above 37.5C°), 37% had myalgia, 36.3% lost their sense of smell and 15% had dyspnea.

Relating symptomatology with weight classification, it is observed that there are no statistically significant differences regarding the existence of symptoms (and type of symptoms), by BMI.

Among the people who reported a positive RT-PCR test, 7 individuals (1.4%) required hospitalization, with 57% classified as normal weight and 43% as overweight, with no statistically significant relationship between these two variables.

A similar situation was recorded in admissions to the Intensive Care Unit, in which only 2 individuals needed it (28%), one classified as normal weight and the other as overweight, with no significant differences being found, once again, in the relationship between BMI and the need for hospitalization in the ICU.

In the immunity analysis, it was found that 7.9% of the sample had an antibody value lower than the immunity threshold defined by the commercial house, with the remaining 92.1% having antibody levels higher than the minimum values proposed as a threshold of immunity. Crossing this variable with the BMI classification, it is observed that there are no statistically significant differences.

4. Discussion

The work includes 1552 individuals, 64% male and the remaining 36% female. The sample had an average age of 48.95 years, with a minimum of 18 years and a maximum of 98 years. This sample was collected in the *Beira Baixa* region, which according to the most recent data available at the National Statistics Institute (on-line) consisted of 80,751 people, thus representing a sample very close to 2%; Still according to this database, the majority of the population of Beira Interior was between 15 and 64 years old, with a predominance of women [17].

In this study, the predominance of males is notable, and it was probably men who were most alerted to the possibility of participating in this study, which has also been commonly found in other

similar studies [18]. Regarding the age group, there is an alignment with the standard values for this population. We highlight the existence of several very old people (over 85 years old), which is a portrait of the population of a rural location, as this region represents.

More than half of the sample population (58.6%) was outside the “normal weight” standards, which is in line with other studies on obesity carried out in the Portuguese population [19, 20, 21].

A note for around 20% of the sample in obesity levels, as it is known from previous studies that this is one of the main factors for respiratory and cardiac pathologies, among others [22, 23].

Body mass index is also known to be related to literacy levels, meaning that normally more rural populations with lower levels of access to healthcare, such as those living in *Beira Baixa*, tend to have lower levels of literacy and hence the values of more than half of the population have a high BMI [24].

The vaccination rate found in this study was very high. One caveat is that the study began at the beginning of the implementation of vaccination and continued until the WHO declared the end of the pandemic. Therefore, the data must be interpreted from this perspective, as they may naturally have fluctuated. A retrospective study analyzed vaccination intentions during the first year of the pandemic and values ranged between 27.7% and 93.3%. Considering that the work has gone through this phase, it is normal that the rate can be observed to be higher, especially because with the successive doses implemented, the Portuguese normally adhered to and reached high vaccination rates. A highlight on the other hand is an article from 2022 that analyzed the rate of hesitancy in vaccination against SARS-COV-2 in 114 countries, which places Portugal with an acceptance rate of just 35%, in contrast to, for example, Canada (91%) and Norway (89%) [25].

Relating data on BMI and vaccination rate, there are statistically significant differences, since individuals with BMI in the highest categories have a greater tendency to be vaccinated. Since the initial phase of the pandemic, obesity has been considered one of the most predisposing factors for negative developments during the course of COVID-19 [26]. Patients with higher BMI had very high mortality levels when compared to individuals with a BMI classified as “normal”, whether associated with other pathologies or not [27]. Probably the sharing of this information either by health services or by the population itself may have contributed to greater availability of these individuals for the vaccination process. Obesity is associated with several other pathologies of a metabolic nature, which further increases the vulnerability of these patients, but also its monitoring in health systems [28] and could therefore be a contribution to its higher vaccination rate.

We can observe that the majority of people were vaccinated only with the Comirnaty vaccine (38.9%), or with this vaccine in combination with another (14.6%). In the case of a combined vaccine between two different ones, it is worth highlighting the fact that Comirnaty is always used in the second or third dose. Thus, more than half of our sample (53.5%) had contact with the Comirnaty vaccine throughout the vaccination process.

Analyzing several international studies, we observed that Comirnaty presented very high efficacy and safety values [29], which could be one of the justifications for these values. We remember that this vaccine was developed by a German technology company (BioNtech) and produced by a North American company (Pfizer), having been the first to obtain all the necessary authorizations for commercialization both in Europe and in the United States. It is based on mRNA, making it possible for there to be no dead or attenuated virus in its constitution, which also from the point of view of people with less literacy could be a positive factor for adherence to vaccination [30].

Indeed, one of the biggest difficulties that vaccination faced was people's adherence to the process, with several obstacles being experienced. The constant misinformation, the overvaluation of incidents that could possibly be related to the vaccination process were the most negative part; On the positive side, we can mention the hope that the creation of vaccines against COVID-19 has brought to humanity, the tireless work of health professionals to demystify the process that led to the creation of vaccines in record time and the effectiveness of themselves, having been one of the greatest contributions to humanity being able to combat this pandemic [31].

These issues became even more acute in the context of vaccinating children, with enormous doubts and fears on the part of parents, as they were always responsible for the final decision to vaccinate or not [32].

As previously mentioned, this work had a long duration, going through the various phases of the pandemic process. The existence of 32.3% of individuals with a positive RT-PCR test is a good example, since according to the most recent data from the General Directorate of Health (DGS), it is estimated that more than 5.5 million people have had contact with SARS-COV-2 in Portugal (<https://www.insa.min-saude.pt/category/areas-de-atuacao/epidemiologia/covid-19-curva-epidematica-e-parametros-de-transmissibilidade/>), which represents a percentage of around 54% of the population residing in Portugal, considering the global value obtained in the 2021 Census [33]. It is also important to highlight that, at this stage, the population uses “self-tests” much more, with no reporting of all cases, with the exception of those diagnosed in Health Units (concurrent with other health situations) or those that present severe symptoms [34]. Therefore, the value obtained in this study reflects, on average, the long trajectory and fluctuations that COVID-19 test reports have had, a consequence, naturally, of the evolution of the pandemic.

Analyzing the existence of a positive test by body mass index, we observed the non-existence of statistically significant differences. Contamination is associated with environmental factors, mainly closed spaces, contact with droplets of saliva and, in general, the proximity between individuals. Obesity is not, individually, a factor that contributes to increasing the probability of contamination by SARS-COV-2, although it is, as we saw previously, a predisposing factor for situations of greater clinical severity [35].

In analyzing the symptoms, it was found that the most common symptoms were headache, cough and sore throat, which is similar to what has been described in most articles [36]. These symptoms were not related to BMI. When classifying the severity of the pathology according to the defined parameters, it was observed that the vast majority (69.8%) had a pathology classified as mild and only 1.4% required hospitalization, of which 28% in Intensive Care Units. Once again, in this parameter, there are no statistically significant differences depending on body mass index, which is contrary to most studies carried out [37, 38], which point to obesity as a potential negative impact on the favorable evolution of COVID-19, although science has not yet definitively explained the direct influence of obesity on the poor prognosis [39].

More than 92% of the sample showed antibody levels compatible with immunity. It was not possible to analyze how this immunity was obtained, specifically whether it is due to the vaccination process or whether it is related to immunity acquired through contact with SARS-COV-2. Cross-referencing this data with the number of people who reported having had a positive RT-PCR test (32.3%) as well as the number of people vaccinated (97.9%), we can admit that the majority of individuals had an immune response. It should also be added that among the individuals who reported not having been vaccinated, 32% showed an immune response, that is, clearly associated with the previous presence of SARS-COV-2 in the body. Vaccines present high levels of safety as well as similar side effects regardless of BMI [27], thus not constituting an increased risk due to the fact that they are administered to people with high BMI.

It is known that vaccination contributes to reducing the risk of negative developments and these values are not influenced by BMI levels [39].

5. Conclusions

This work is very important as it allows us to increase knowledge about the COVID-19 pathology in a specific area of Portugal, which has very particular characteristics, as it is in the interior of the country, has enormous desertification, a very low population rate, a vast area of territory, with road access not always very capable of responding to the needs of the population and with health institutions that often have exacerbated limitations in human and technical resources.

With this work, we specifically intend to study one of the pathologies that has been most analyzed as a negative factor in the evolution of COVID-19. In fact, we realize that many studies have

considered the relationship between this variable and the impact of SARS-COV-2 infection, but at the same time there are many doubts that remain.

Among the main conclusions, it is observed that individuals with a higher BMI are more likely to be vaccinated against SARS-COV-2. It is also observed that in the remaining parameters analyzed, namely in the severity of the pathology and associated symptoms, there were no statistically significant differences, considering the stratification of the sample by BMI.

As main limitations we can highlight the duration of data collection, due to the fact that it is a working basis obtained from the epidemic phase until mid-2023 and naturally the evaluation of the data has to take this factor into account. But the importance of being able to convey the various phases with reality is also an essential point, which should be valued. It also has the added value of being able to reflect, in a very approximate way, the reality of the population in which it operates.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Polytechnic Institute of Castelo Branco on July 14, 2021 (33/CE-IPCB 2021).

Informed Consent Statement: Informed consent was obtained from all individuals involved in the study, to whom the entire process of data collection, processing, analysis and dissemination was explained.

Data Availability Statement: There is a database created in this project, which can be consulted by researchers who demonstrate this interest.

Conflicts of Interest: The research team declares that it has no conflict of interest.

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